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Effects of Parity Number on Some Reproductive Parameters in Landrace x Yorkshire Sows

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ABSTRACT

In this study, we evaluated the effects of parity on different reproductive parameters including gestation length (GL), litter size (LS), litter birth weight (LBW), mean individual birth weight (MBW), and number of born dead piglets per litter (BDP) in Landrace x Yorkshire sows. Data was collected from 773 litters born from 773 sows raised on one farm in Northern Vietnam. Based on parity number, sows were categorized into 5 groups, *i.e.*, 1, 2, 3-5, 6-7, and >7. One-way analysis of variance tests was used to compare the GL, LS, LBW, MBW, and BDP among the 5 groups. Results showed that parity significantly affected all the studied reproductive parameters. GL was longest in parities 1 and 6-7 (P<0.05). LS, LBW, and MBW were lowest in parity 1 (P<0.05) and remained stable in the later parities. BDP increased when the parity increased with the lowest value in parity 1 and highest values in parities 6-7 and >7 (P<0.05). This result enriches the understanding of the effect of parity on reproductive performance and may contribute to the management and culling strategies on farms to maximize the farm's benefit.

Key words: Birth weight, Litter size, Parity, Reproductive performance, Sows, Stillbirth

INTRODUCTION

Farm benefit largely depends on the sows' reproductive performance which includes a wide range of parameters such as the total number of piglets born, the number of piglets born alive, and the number of piglets weaned per sow per year (Koketsu et al. 2017; Klimas et al. 2020). In recent decades, LS, perhaps, has been the most improved reproductive parameter due to the improvement in genetic selection, nutrition, and management (Koketsu et al. 2017). Several studies reported that LS increased from parity 1 to parity 5 or 6 and then decreased (Bratte et al. 1997; Imboonta and Kuhaaudomlarp 2012). Other studies found that LS in parities 3-5 was similar to that in parities 6-8 (Milligan et al. 2002) or LS in parity 1 was similar to that in parity 4 (Carney-Hinkle et al. 2013). Dissimilarity in results among studies may be due to the difference in breeds, nutrition, management, and culling strategies.

The selection of highly prolific sows increased LS but it reduced birth weight (BW) and increased stillbirth rate (Rangstrup-Christensen et al. 2017; van den Bosch et al. 2022). The effect of parity on BW is controversial. Some authors reported that BW in parities 2-4 was higher than that in parity 1 (Carney-Hinkle et al. 2013; Lavery et al. 2019; Nuntapaitoon et al. 2020; Segura et al. 2020). Other authors demonstrated that parity had no effects on BW (Wientjes et al. 2012). Similarly, different studies reported inconsistent associations between stillbirth and parity. Many studies showed that stillbirth rate was positively associated with parity (Vanderhaeghe et al. 2010; Vanderhaeghe et al. 2011; Pandolfi et al. 2017; Nam and Sukon 2020a). Other authors found that the stillbirth rate was high in the first parity, reduced in the second parity and increased in later parities (Nam and Sukon 2020b).

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The understanding of the effect of parity on reproductive performance will contribute to the management of sows and maintenance of an ideal herd structure for maximizing farm benefit. Therefore, in this study we aimed to evaluate the effects of parity on different reproductive parameters including GL, LS, LBW, MBW, and BDP in Landrace x Yorkshire sows.

MATERIALS AND METHODS

Ethical Approval

All the procedures used in this study were routinely conducted on the investigated farm, therefore, the ethical approval was waived from the Committee on Animal Research and Ethics, Faculty of Veterinary Medicine, Vietnam National University of Agriculture, Vietnam.

Animals and housing

This study used the data collected from 773 Landrace x Yorkshire sows raised on one farm in Northern Vietnam between October 2022 and February 2023. The studied farm has a capacity of 2400 breeding sows. These included sows born to 773 litters with 10522 piglets. Vaccines against porcine reproductive and respiratory syndrome, classical swine fever, foot and mouth diseases, pseudorabies and circovirus. Deworming was conducted twice per year. Each sow was kept in a separate gestation crate and farrowing crate which were in a similar size. During sows' gestation, they were fed 1.8-3.5kg per day and received water *ad libitum*. Fans, sprinklers, and infrared light were used to control the temperature in the gestation and farrowing rooms. The temperature in the pregnant and farrowing rooms was about 17-28°C. Both rooms were lit about 10h per day, but during the farrowing days, the farrowing room was lit 24h per day. The humidity in both rooms varied between 70-80%. Sows were kept in individual crates which were about 60x220cm in both pregnant and farrowing rooms. Pregnant sows were moved to farrowing rooms about one week before farrowing. Sows were fed 1.0-1.5kg/day from day 112 of gestation. On farrowing day, sows were not provided with feed. After farrowing, the feed level was gradually increased to meet the requirement of the sows which was usually 6kg/day at day 6 postpartum. All sows were administered with amoxicillin trihydrate (Hitamox LA, 15mg/kg, Thainaoka, Thailand) and oxytocin (Oxytocin, 20IU, Hanvet, Vietnam) postpartum for about 3-5 days.

Data collection and definition

Parity numbers were collected from the sow card. GL was calculated as the period from the first insemination to farrowing. LS (born alive piglets, stillbirths and mummies) and the BDP (stillbirths and mummies) per litter were recorded. LBW was the pooled weight of all piglets born to a given litter which were weighed at the same time using a digital scale. MBW was calculated by dividing LBW by the LS of a given litter. During farrowing sows might be injected with oxytocin or assisted with fetal removal manually, however, this information was not recorded.

Statistical analysis

Descriptive statistics including mean, standard deviation, percentage, and 25th percentile were used for the calculation of various values of different reproductive parameters. To study the effect of parity on different reproductive criteria, parity was partitioned into 5 groups, *i.e.*, 1, 2, 3-5, 6-7, and >7. The effect of parity on GL, LS, LBW, MBW, and BDP were analyzed using the analysis of variance (one-way ANOVA) in the Statistical Package for the Social Sciences (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp). When the P value was less than 0.05 the difference was considered significant.

RESULTS

The GL varied between 110 and 126 days averaging 115.76 days. About 7.8% of sows had a GL shorter than 114 days, 87.1% of sows had a GL of 114-118 days, and 5.2% of sows had a GL than 118 days. The most frequent GL was 115 days (23.0%) and then 116 days (20.7%). The smallest LS was 2 and the largest one consisted of 24 piglets. Sixteen percent of sows had a LS of 2-10, 64.8% of sows gave birth to 11-16 piglets and the rest (19.1%) had a LS of 16-24. On average, the LS was 13.61±3.59 piglets/litter. The average LBW was 18.98±5.20kg varying from 4.4 to 34.58kg. The 25th, 50th, and 75th percentiles of LBW were 15.6, 18.9, and 22.3kg, respectively. The MBW of piglets was 1.39±0.23 kg. The 25th, 50th, and 75th percentile of MBW was 1.25, 1.36, and 1.54kg, respectively. On average, about 0.89 piglets were born dead per litter. Forty-four percent (44.0%) of litters had at least 1 stillborn and/or mummified piglets of which 50.9 and 25.6% litters had 1 and 2 stillborn and/or mummified piglets, respectively.

Parity had significant effects on all the studied reproductive parameters including GL, LS, LBW, MBW, and BDP. The GL of sows in parities 2 and 3-5 was shorter than that in parities 1 and 6-7 (P<0.05). LS in parity 1 was smaller than those in other parities (P<0.05). No significant difference in LS among sows in parities >1 was detected. Parity 1 sows had the smallest LBW in comparison with sows in other parities (P<0.05). LBW was not significantly different among sows in parities >1. Similarly, MBW was smallest in the piglets born from parity 1 sows. No difference in MBW of the piglets born among sows in parities >1 was found. The BDP was lowest in parity 1, and highest in parities 6-7 and >7 (P<0.05) (Table 1).

Table 1: Effects of parity on gestation length, litter size, liter birth weight, mean individual birth weight, and number of born dead piglets per litter

Parameters	Parity=1 (n=177)	Parity=2 (n=123)	Parity=3-5 (n=237)	Parity =6-7 (n=155)	Parity>7 (n=81)
GL (day)	116.01±1.94^{a}	115.51±1.51^{b}	115.53±1.77^{b}	116.01±2.10^{a}	115.86±2.10^{ab}
LS (piglets/litter)	12.37±3.05^{a}	13.72±3.74^{b}	14.21±3.63^{b}	14.04±3.71^{b}	13.60±3.57^{b}
LBW (kg)	16.81±4.86^{a}	19.42±5.03^{b}	19.95±4.87^{b}	19.78±5.48^{b}	18.69±5.28^{b}
MBW (kg)	1.32±0.17^{a}	1.43±0.23^{b}	1.42±0.24^{b}	1.42±0.25^{b}	1.39±0.19^{b}
BDP (piglets/litter)	0.53±1.02^{a}	0.89±1.62^{bc}	0.83±1.30^{b}	1.23±1.93^{c}	1.22±1.67^{c}

^{a,b,c} Within the same row, a mean with different superscripts indicated a statistical significance (P<0.05); GL: gestation length; LS: litter size; LBW: litter birth weight; MBW: mean individual birth weight; BDP: number of born dead piglets per litter. Data are presented as mean ±SD

DISCUSSION

This study evaluated the effect of parity on different reproductive parameters in Landrace x Yorkshire crossbred sows and showed that parity had a significant impact on GL, LS, MBW, LBW, and BDP.

Previous studies reported inconsistent findings on the effect of parity on GL (Bratte et al. 1997; Imboonta and Kuhaaudomlarp 2012; Yang and Jeon 2019; Segura et al. 2020). Segura et al. (2020) found that the average GL from parity 1 to parity >5 varied from 114.4 to 115.0 without any significant difference. By contrast, Yang and Jeon (2019) observed the longest GL in parity 6-9. However, the results by Yang and Jeon (2019) might not reasonably represent other sow populations because that study consisted of only 20 sows and the biggest LS in the first parity contrasted to widely known increased LS with parity in pig (Koketsu et al. 2017). In another study, Bratte et al. (1997) found that GL was longer in the parity 5-6 than in the parity 2. The results of the present study were partly in line with that of Imboonta and Kuhaaudomlarp (2012) who documented that the GL was longest in the first parity. However, in that study, the GL in parity 2, 3, 4, 5, and ≥6 was very close together. The longer GL in parity 1 in comparison with that in parities 2-5 found in the present study might be explained via the unproportionately association between GL and LS (Imboonta and Kuhaaudomlarp 2012; Yang and Jeon 2019; Bumpenkul and Imboonta 2021). Such an association also existed in the present study (Pearson's correlation=-0.104, P=0.004). LS positively correlated with estrogen level during the last 3 weeks of gestation. Because ovariectomy did not decrease the estrogen level in pregnant sows (Fèvre et al. 1968), it was suggested that the estrogen originated from the placenta (Fèvre et al. 1968; Ellendorff et al. 1979). Meanwhile, the placental weight was strongly correlated with LS (r=0.7) (Vernunft et al. 2018). Therefore, the larger the LS the heavier the placenta and the more estrogen was produced. During late gestation, estrogen level was negatively associated with progesterone level (Martin et al. 1977). As a result, at the prepartum stage, a sow with a larger LS in parities 2-5 might have a greater estrogen level and a smaller progesterone level which might shorten her GL. Nevertheless, the proposed mechanism could not explain the increased GL in parities 6-7 in comparison with that in parity 2-5. Uterine contraction is known to decrease with age in both women and animals (Main et al. 2000; Elmes et al. 2015). Therefore, long GL in the parities 6-7 may be due to weaker contraction of uterine tissue resulting in late opening of cervices in these sows.

The smallest LS in the 1st parity and peak one in parity 3-5 found in this study were in agreement with many other previous findings (Bratte et al. 1997; Škorjanc et al. 2007; Schwarz et al. 2009; Nuntapaitoon et al. 2020; Klimas et al. 2020). Some others reported a nonsignificant effect of parity on LS (Carney-Hinkle et al. 2013; Segura Correa et al. 2013). LS may be influenced by many factors such as ovulation and fertilization rates, quality of oocytes and sperms, time of insemination, uterine nursing capacity, placental efficiency, nutrition, diseases, and management. On one hand, among the abovementioned factors, the intrinsic ones such as ovulation rate, uterine size, and placental efficiency may be parity-dependent. The ovulation rate in gilts is inferior to that in sows (Foxcroft et al. 2006; Kemp et al. 2018). When the parity increased the sow's body weight also increased (Vernunft et al. 2018), and the body weight of the sows positively correlated with the uterine length (Tummaruk and Kesdangsakonwut 2014). In women, the uterine size increased with the increased parity (Benacerraf et al. 2010). Furthermore, placental efficiency was found to increase with parity in lambs, mares, and alpacas (Wilsher and Allen 2003; Dwyer et al. 2005; Bravo et al. 2009). These findings suggested that the pigs' uterine size and placental efficiency might also increase with the parity. The increase in the ovulation rate, the size of uterus, and the efficiency of the placenta contributed to the increased LS in multiparous sows in comparison with primiparous counterparts. On the other hand, the increase in LS with parity may be due to the selection and culling of the sows after each parity in which sows with low LS are at a higher risk of being culled (Segura-Correa et al. 2011; Lucia et al. 2000).

Effects of parity on MBW, LBW, and BDP found in this study were in a similar pattern. Carney-Hinkle et al. (2013) found a higher MBW and LBW in parity 4 in comparison with that in parity 1. A quadratic association between parity and piglet BW was observed by Nuntapaitoon et al. (2020) in which the BW increased from parity 1 to parities 2-4 and decreased in parities 5-6. Škorjanc et al. (2007) reported a negative correlation between parity and piglet BW. Stillbirth also increased with an increase in parity (Vanderhaeghe et al. 2010). The lowest LBW and BDP in parity 1 seemed to be attributable to the smallest LS in parity 1. However, the lowest MBW in parity 1 might be due to a lower placental efficiency in this group as discussed above. Another potential reason was that gilts had not got their full corporal development at their first gestation, and energy intake during this period was partitioned into both pursuing maturity and nurturing fetuses (Whittemore 1996). Regarding the positive association between the BDP and parity, the positive association between parity and farrowing duration (Björkman et al. 2017) might be an explanation because farrowing duration has been known to increase the risk of stillbirths (Nam and Sukon 2020a; Lanh and Nam 2022).

Conclusion

In conclusion, the present data indicated that parity had significant effects on GL, LS, MBW, LBW, and BDP. Parity 1 sows had longer GL and lower LS, LBW, MBW, and BDP when compared to multiparous sows. This result enriches the understanding of the effects of parity on reproductive performance and may contribute to the management and culling strategies on farms to maximize the farm's benefit.

Author contributions

NHN, TK, DTKL, NVT, NDT, NCT, BVD, BTAD, PS: Conception. NHN, PS: Data analysis. NHN: Drafted manuscript. All authors read, reviewed, criticized, and approved the final manuscript.

Conflict of interest

None.

REFERENCES

Benacerraf BR, Shipp TD, Lyons JG and Bromley B, 2010. Width of the normal uterine cavity in premenopausal women and effect of parity. Obstetrics and Gynecology 116: 305-310. https://doi.org/10.1097/AOG.0b013e3181e6cc10

Björkman S, Oliviero C, Rajala-Schultz PJ, Soede NM and Peltoniemi OAT, 2017. The effect of litter size, parity and farrowing duration on placenta expulsion and retention in sows. Theriogenology 92: 36-44. https://doi.org/10.1016/j.theriogenology.2017.01.003

Bratte L, Ikhimioya I and Arijeniwa A, 1997. Reproductive Performance in Relation to Parity in Yorkshire x Landrace Pigs Reared Intensively in the Humid Tropics of South Western Nigeria. Journal of Applied Animal Research 12: 197-202. https://doi.org/10.1080/09712119.1997.9706207

Bravo PW, Garnica J and Puma G, 2009. Cria alpaca body weight and perinatal survival in relation to age of the dam. Animal Reproduction Science 111: 214-219. https://doi.org/10.1016/j.anireprosci.2008.03.001

Bumpenkul R and Imboonta N, 2021. Genetic correlations between gestation length and litter traits of sows. The Thai Journal of Veterinary Medicine 51: 675-682. https://doi.org/10.56808/2985-1130.3165

Carney-Hinkle EE, Tran H, Bundy JW, Moreno R, Miller PS and Burkey TE, 2013. Effect of dam parity on litter performance, transfer of passive immunity, and progeny microbial ecology. Journal of Animal Science 91: 2885-2893. https://doi.org/10.2527/jas.2011-4874

Dwyer CM, Calvert SK, Farish M, Donbavand J and Pickup HE, 2005. Breed, litter and parity effects on placental weight and placentome number, and consequences for the neonatal behaviour of the lamb. Theriogenology 63: 1092-1110. https://doi.org/10.1016/j.theriogenology.2004.06.003

Ellendorff F, Taverne M, Elsaesser F, Forsling M, Parvizi N, Naaktgeboren C and Smidt D, 1979. Endocrinology of parturition in the pig. Animal Reproduction Science 2: 323-334. https://doi.org/10.1016/0378-4320(79)90056-3

Elmes M, Szyszka A, Pauliat C, Clifford B, Daniel Z, Cheng Z, Wathes C and McMullen S, 2015. Maternal age effects on myometrial expression of contractile proteins, uterine gene expression, and contractile activity during labor in the rat. Physiological Reports 3: e12305. https://doi.org/10.14814/phy2.12305

Fèvre J, Léglise PC, Rombauts P and Reynaud O, 1968. Du rôle de l'hypophyse et des ovaires dans la biosynthèse des oestrogènes au cours de la gestation chez la truie. InAnnales de Biologie Animale Biochimie Biophysique 8(2): 225-233.

Foxcroft GR, Dixon WT, Novak S, Putman CT, Town S and Vinsky MD, 2006. The biological basis for prenatal programming of postnatal performance in pigs. Journal of Animal Science 84: E105-112. https://doi.org/10.2527/2006.8413_supplE105x

Imboonta N and Kuhaaudomlarp P, 2012. Genetic Associations between Stillbirth, Total Number of Piglets Born and Gestation Length in a Commercial Pig Farm. The Thai Journal of Veterinary Medicine 42: 165-172. https://doi.org/10.56808/2985-1130.2378

Kemp B, Da Silva CLA and Soede NM, 2018. Recent advances in pig reproduction: Focus on impact of genetic selection for female fertility. Reproduction in Domestic Animals 53(2): 28-36. https://doi.org/10.1111/rda.13264

Klimas R, Klimiené A, Sobotka W, Kozera W and Matusevicius P, 2020. Effect of parity on reproductive performance sows of different breeds. South African Journal of Animal Science 50: 434-441. http://dx.doi.org/10.4314/sajas.v50i3.10

Koketsu Y, Tani S and Iida R, 2017. Factors for improving reproductive performance of sows and herd productivity in commercial breeding herds. Porcine Health Management 3(1): 1-10. https://doi.org/10.1186/s40813-016-0049-7

Lanh DTK and Nam NH, 2022. High stillbirth rate in a swine farm in Vietnam and associated risk factors. Journal of Advanced Veterinary and Animal Research 9: 13-18. https://doi.org/10.5455/javar.2022.i564

Lavery A, Lawlor PG, Magowan E, Miller HM, O'Driscoll K and Berry DP, 2019. An association analysis of sow parity, live-weight and back-fat depth as indicators of sow productivity. Animal 13: 622-630. https://doi.org/10.1017/S1751731118001799

Lucia T, Dial GD and Marsh WE, 2000. Lifetime reproductive performance in female pigs having distinct reasons for removal. Livestock Production Science 63: 213-222. https://doi.org/10.1016/S0301-6226(99)00142-6

Main DM, Main EK and Moore DH, 2000. The relationship between maternal age and uterine dysfunction: a continuous effect throughout reproductive life. American Journal of Obstetrics and Gynecology 182: 1312-1320. https://doi.org/10.1067/mob.2000.106249

Martin PA, Bevier GW and Dziuk PJ, 1977. The effect of number of corpora lutea on the length of gestation in pigs. Biology of Reproduction 16: 633-637. https://doi.org/10.1095/biolreprod16.5.633

Milligan BN, Fraser D and Kramer DL, 2002. Within-litter birth weight variation in the domestic pig and its relation to pre-weaning survival, weight gain, and variation in weaning weights. Livestock Production Science 76: 181-191. https://doi.org/10.1016/S0301-6226(02)00012-X

Nam HN and Sukon P, 2020a. Risk factors associated with stillbirth in swine farms in Vietnam. World Veterinary Journal 10: 74-79. https://dx.doi.org/10.36380/scil.2020.wvj10

Nam HN and Sukon P, 2020b. Risk factors associated with stillbirth of piglets born from oxytocin-assisted parturitions. Veterinary World 13: 2172-2177. https://doi.org/10.14202/vetworld.2020.2172-2177

Nuntapaitoon M, Juthamanee P, Theil PK and Tummaruk P, 2020. Impact of sow parity on yield and composition of colostrum and milk in Danish Landrace × Yorkshire crossbred sows. Preventive Veterinary Medicine 181: 105085. https://doi.org/10.1016/j.prevetmed.2020.105085

Pandolfi F, Edwards SA, Robert F and Kyriazakis I, 2017. Risk factors associated with the different categories of piglet perinatal mortality in French farms. Preventive Veterinary Medicine 137: 1-12. https://doi.org/10.1016/j.prevetmed.2016.12.005

Rangstrup-Christensen L, Krogh MA, Pedersen LJ and Sørensen JT, 2017. Sow-level risk factors for stillbirth of piglets in organic sow herds. Animal 11: 1078-1083. https://doi.org/10.1017/S1751731116002408

Schwarz T, Nowicki J and Tuz R, 2009. Reproductive performance of Polish Large White sows in intensive production - effect of parity and season. Annals of Animal Science 9: 269–277.

Segura-Correa JC, Ek-Mex E, Alzina-López A and Segura-Correa VM, 2011. Frequency of removal reasons of sows in Southeastern Mexico. Tropical Animal Health and Production 43: 1583-1588. https://doi.org/10.1007/s11250-011-9847-8

Segura Correa JC, Alzina-López A and Santos-Ricalde RH, 2013. Risk factors associated with the occurrence of the second-litter syndrome in sows in southeastern Mexico. Scientific World Journal 2013: 969620. https://doi.org/10.1155/2013/969620

Segura M, Martínez-Miró S, López MJ, Madrid J and Hernández F, 2020. Effect of Parity on Reproductive Performance and Composition of Sow Colostrum during First 24 h Postpartum. Animals 10: 1853. https://doi.org/10.3390/ani10101853

Škorjanc D, Brus M and Čandek Potokar M, 2007. Effect of Birth Weight and Sex on Pre-Weaning Growth Rate of Piglets.

Archives Animal Breeding 50: 476-486. https://doi.org/10.5194/aab-50-476-2007

Tummaruk P and Kesdangsakonwut S, 2014. Uterine size in replacement gilts associated with age, body weight, growth rate, and reproductive status. Czech Journal of Animal Science 59: 511-518. https://doi.org/10.17221/7732-CJAS

van den Bosch M, van de Linde IB, Kemp B and van den Brand H, 2022. Disentangling litter size and farrowing duration effects on piglet stillbirth, acid–base blood parameters and pre-weaning mortality. Frontiers in Veterinary Science 9: 836202. https://doi.org/10.3389/fvets.2022.836202

Vanderhaeghe C, Dewulf J, De Vliegher S, Papadopoulos GA, de Kruif A and Maes D, 2010. Longitudinal field study to assess sow level risk factors associated with stillborn piglets. Animal Reproduction Science 120: 78-83. https://doi.org/10.1016/j.anireprosci.2010.02.010

Vanderhaeghe C, Dewulf J, Jourquin J, De Kruif A and Maes D, 2011. Incidence and prevention of early parturition in sows. Reproduction in Domestic Animals 46: 428-433. https://doi.org/10.1111/j.1439-0531.2010.01685.x

Vernunft A, Maass M and Brussow KP, 2018. Placental characteristics of German Landrace sows and their relationships to different fertility parameters. Czech Journal of Animal Science 63: 339-346. https://doi.org/10.17221/23/2017-CJAS

Whittemore CT, 1996. Nutrition reproduction interactions in primiparous sows. Livestock Production Science 46: 65-83. https://doi.org/10.1016/0301-6226(96)00019-X

Wientjes JGM, Soede NM, van der Peet-Schwering CMC, van den Brand H and Kemp B, 2012. Piglet uniformity and mortality in large organic litters: Effects of parity and pre-mating diet composition. Livestock Science 144: 218-229. https://doi.org/10.1016/j.livsci.2011.11.018

Wilsher S and Allen WR, 2003. The effects of maternal age and parity on placental and fetal development in the mare. Equine Veterinary Journal 35: 476-483. https://doi.org/10.2746/042516403775600550

Yang KY and Jeon JH, 2019. Effect of different parities on reproductive performance, birth intervals, and tail behavior in sows. Journal of Animal Science and Technology 61: 147-153. https://doi.org/10.5187/jast.2019.61.3.147